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THE MILLSTONE GRIT SEQUENCE BETWEEN MASHAM AND GREAT WHERNSIDE.

BY W. S. BISAT.

(READ SEPT. 20TH, 1913).

The district in which the rocks under discussion are situated is bounded on the N.W. by Coverdale, east by the Valley of the Ure, west by Wharfedale, S.E. by the watershed dividing the Burn and Laver valleys, and on the S.W. by an arbitrary line running due west from Ramsgill into Wharfedale.

The whole of the Millstone Grit sequence is not seen in this area, beds which have been referred to the top of the Third Grits being the highest that have escaped denudation.

It is of course well known that the succession consists of the usual alternations of grits, sandstones and shales, but owing to the variation horizontally and general similarity of the sandstone and grit bands, it does not appear possible or useful to attempt any division of the series based on the occurrence of grit or sandstone beds at varying horizons.

Marine fossils occur at two well-defined horizons, and it is proposed to make use of these two bands as a basis for the subdivision of the sequence.

Phillips in his "Geology of the Mountain Limestone District" (pp. 209-212) published in 1836, records five marine fossils from Colsterdale on the authority of Danby.

The Rev. J. S. Tute recorded from the neighbourhood of Ripon (Proc. Yorks. Geol. Socy., 1867 and 1886), a list of marine fossils from an horizon in the Third Grits which he termed the Cayton Gill Beds on account of their being well exposed in Cayton Gill, near Ripon. From the same neighbourhood Dr. Wheelton Hind has since recorded (*The Naturalist*, 1907, pp. 92, 93) a much fuller list, and the mapping of the Survey indicated that these beds continued as a fossiliferous horizon as far north as Masham.

The excavation of the trench for the core wall at Leighton Reservoir, near Masham, for the Leeds City Council, though unfortunately mainly passing through beds of a barren character, has provided an opportunity for making a fairly detailed examination of the sequence, the determination of the relative position of the two marine bands above alluded to, and the obtaining of satisfactory aunal lists therefrom.

Colsterdale Fossiliferous Band, as seen at Backstone Gill, Meugher Fell, Upper Nidderdale.

Proc. Yorks. Geol. Soc., Vol. XIX. Plate II.

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Using the two well established fossiliferous horizons to split up the series, we obtain the following groups of beds :—

Brimham Grit Group	350 ft.
Cayton Gill Beds	150 ft.
Barren Beds	250 ft.
Colsterdale Fossil Beds	10 ft.-80 ft.
Basement Shales	say 300 ft.-400 ft.
Basement or Bearing Grit... ...	0 ft.-200 ft.

The thicknesses given to the first three sections are of the series as developed at Clints, near Leighton Reservoir, Masham ; the thickness of the Colsterdale fossiliferous horizon (Plate II.) appears to vary to the indicated extent ; and the thickness of the basement shales is estimated from the Coverdale exposures.

These basement shales, which together with the basement or Bearing Grit form the lowest beds in the series, lie on a variable base, which is seen in Nidderdale and Coverdale ; and indications of erosion, which may be responsible for a good deal of the variation, are not lacking. The Bearing Grit, above alluded to, is seen very well in Howstean Beck and Blayshaw Gill near Lofthouse-in-Nidderdale, and appears to attain a maximum thickness along a north and south line under Great Whernside. The shales are usually fairly sandy, and contain some small sandstone bands, but are generally of a limp character. They are to some extent micaceous, and thin coals occur near the base. Occasional small obscure shells are met with, but I have not yet had the opportunity of examining the whole of the thickness, and a good deal of work remains to be done in the examination of these shales, and the underlying junction with the Yoredale limestones.

At the top of the above shales a sandstone or grit band occurs almost everywhere, with a coal seam in part of the area. This coal seam has been worked in Coverdale, Nidderdale and Colsterdale, has a thickness varying up to 1 ft. 6 in. or 2 ft., and is a useful guide to horizon. It is followed by shales containing a marine fauna. These fossiliferous shales may be traced from Colsterdale to Great Whernside and southwards from thence along the borders of Nidderdale and Wharfedale. Along this latter line the thickness of fossiliferous shale does not appear to be more than 10 ft., including a thin limestone band about a foot in thickness, which has been mapped and named by the Survey the " Tesselated Limestone " ; but the fossiliferous

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group thickens out to the north-east in Colsterdale, mainly owing to grit bands coming in. Here trial holes were sunk some years ago by the Leeds City Council for their water scheme, and the material tipped to spoil has yielded a fairly large fauna. The coal seam may be taken as forming the base of the fossiliferous group, but unfortunately there are no exposures showing the whole series, and failing this, it is not easy to assign any definite thickness to these beds, but lacking better evidence, about 80 ft. of beds may be taken as here belonging to the marine band, which thickness includes about 40 ft. of grit and ganister which seem to have fossiliferous layers.

Above these fossiliferous shales there is a thickness of about 250 ft. of sandstones, plates and shales, often very micaceous and apparently barren of any marine fauna. The sandstone bands are not of very great thickness, and very often merely seem to be long lenticular wedges. The thickest band seen is a well marked grit running down the east side of Birk Gill, where it forms the moor top. On reaching Healey Pasture quarry it has become finer grained and is not definitely traceable further south. Its thickness is 50 ft. to 60 ft., it occurs in the middle of the series, and is perhaps represented by rock bands seen at Leighton Reservoir and below Healey, but there appears to be no means of correlation. The shales form at Leighton about 60 per cent of the series, are fairly hard and sandy, and usually full of hard fine grained grey sandstone streaks, which may in a few feet horizontally change the shale into a sandstone. These sandstones contain large concretions of sandstones with a calcite matrix.

The above series of barren beds possesses on the whole strong features, and forms a cap in many places to the relatively softer beds below. Beds at this horizon form a capping to the Nidderdale hills in the neighbourhood of Great Whernside, but are best seen in the valley of the Burn, where characteristic exposures of alternating sandstone and sandy shale may be seen in most of the small gills and in the river Burn itself.

At the top of this series of barren beds there have been small exposures on the south side of the valley at Leighton Reservoir which show what appears to be a definite line of erosion of greater magnitude than the small signs of contemporaneous erosion that occasionally may be seen in these beds. Not only is the erosion line fairly well marked, but also the overlying sediments are of totally different character. The sandstones are thin and contain thick clay partings, and the shales are extremely argillaceous, a character which the shales

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in the whole of the 250 ft. intervening between this horizon and the underlying Colsterdale beds never assume, and only remotely approach in extreme cases. The channel formed by this erosion line appears to run north-east and south-west.

The shales above the erosion line have yielded *Lingula mytiloides*, and in the sandstone beds which follow a fauna especially rich in lamellibranchs is developed. This sandstone bed is the main shellbed of the Cayton Gill series, which may be taken as commencing at the erosion line. Unfortunately only the lowest and least fossiliferous part of this series was exposed at Leighton, but at Roundhill Reservoir, Arnagill Valley, High Ash Head Moor, and in the river Burn, near Shaw's Bridge, Swinton, more fossiliferous beds are exposed, and boulders may be seen strewing the line of outcrop. A dark, platy sandstone higher up in the series is seen at Arnagill Valley and High Ash Head Moor, and has yielded numerous brachiopods, but no lamellibranchs. A similar band on the bank of the Ure, near Hackfall, probably represents the same horizon. The boring at Roundhill noted on page 59 of Fox-Strangways' "Geology of the Country north and east of Harrogate," passed through the whole of this series, and indicated about 60 ft. of shales in the upper part, which unfortunately do not appear to be exposed anywhere in the district. There is some little difficulty in determining the exact thickness to assign to the Cayton Gill Beds as the top is nowhere seen owing to lack of exposures. The total thickness is here taken as 150 feet, which allows the shales immediately below the lower grit band of the Brimham Grit group to be included with the grits.

Beds of this age form the moor top to the east of Lofthouse, and stretch northwards round the bend of Nidderdale to Great Haw. In the region between Great Haw and the head of Grimes Gill a hard white ganisteroid sandstone appears low down in the Cayton Gill series, apparently underlying the main shell bed.

The base of the series at Leighton is mainly formed of clay shales, and this appears to be the case wherever exposures are available, similar shales being seen at Woo Gill, Nidderdale, and traces in Arnagill Valley and Ger Beck, Tranmire. These shales have only yielded *Lingula*, and that but sparingly. Shales a little higher are more fossiliferous.

The sandstone beds seen at Fountains, near Ripon, are much harder and more calcareous than those of this district.

It is not possible owing to lack of exposures to give much detail of the Brimham Grit group. There are two strong grit bands, one of which is quarried. The quarry baring shows overlying this grit band shales which are fairly argillaceous, and to some extent resemble the beds at the base of the Cayton Gill series, though they contain no fauna. There are one or two thin layers of coaly shale. They differ from the barren bed shales in the absence of the strong sandstone streaks which pervade the latter, and also their colour is much lighter.

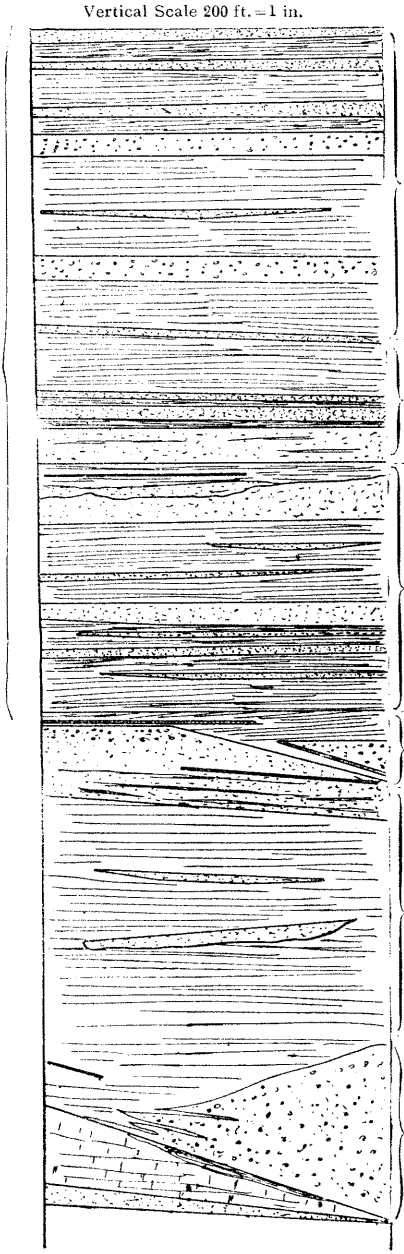
Taking the whole series into consideration the fact emerges that the real clay shales are confined to one or other of the two bands which contain a fauna, and thus it would appear that the conditions which were favourable to abundant marine life usually led to the formation of shales of a clayey rather than a sandy type.

Dr. Hind states that the Colsterdale fauna has a Pendleside facies, and it appears to be a question for further investigation whether these lower beds are not really the northern equivalent of the Pendleside shales further south.

In conclusion, thanks are due to Dr. Wheelton Hind for the identification of the fauna, and to the officials of the Leeds, Harrogate, and Bradford Corporations for permission to visit tips and for information as to sections.

TABLE I.

Diagrammatic Section of the MILLSTONE GRIT sequence as seen between MASHAM and GREAT WHERNSIDE.



Orthoceras morrisianum
Stroboceras bisulcatum
,, *sulcatum*
Allerisma tumida
,, *sulcata*
Aviculopecten clathratus
,, *dissimilis*
,, *occidentalis*
Ctenodonta lævirostris
Edmondia senilis (rudis)
,, *sulcata*
Grammatodon obtusum
Leiopteria laminosa
,, *thompsoni*
Myalina peralata
,, *verneuilli*
Derbya hindi
Productus carbonarius
,, *cora*
Nucula æqualis
,, *luciniformis*
Nuculana stilla
Finna mutica
Posidoniella elongata
Protoschizodus axiniformis
,, *curtus*
Schizodus antiquus
,, *wheeleri*
Sanguinolites tricostatus
,, *modiolaris*
Spathella lata
Scaldia benedeniana
Sedgwickia transversa
Tellinomorpha transversa
Chonetes laguessiana
Schizophoria resupinata
Productus concinnus
,, *semireticulatus*
Etc.

Sandstone plates and shales. Shales (at Leighton) form about 60% of the series, are very strong and sandy, full of thin, grey, fine-grained sandstone streaks, thus making a hard, strong group. No coal seams, no clay shales, no fauna. Carbonaceous markings, occasional ripple marks, micaceous layers, calcite concretions. Sandstones not usually very coarse, except to north and west. Individual beds extremely variable.

Glyphioceras diadema
,, *micronotum*
,, *phillipsi*
Orthoceras asiculare
,, *koninckianum*
Nomismoceras spirorbis
Allorisma sulcata
Aviculopecten occidentalis
,, *gentilis*
Ctenodonta lævirostris
Myalina peralata
Nucula gibbosa
,, *æqualis*
,, *luciniformis*
Nuculana attenuata
,, *stilla*
Posidoniella corrugata
,, *kirkmani*
,, *lævis*
Posidonomya membranacea
Prothyris elegans
Etc.

Shales with a flagstone to grit top, and small sandstone bands at varying intervals. Shales generally limp and micaceous, with thin coals near the base in Nidderdale and Coverdale (Upper). Occasional obscure fossils.

Rapidly develops on a north and south axis through Great Whernside, and appears to bend south easterly towards Lofthouse-in-Nidderdale, where grit is seen at the base of the series in Howstean Beck and Blayshaw Gill.

FIG. 1.

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TABLE II.

FAUNA OF THE COLSTERDALE MARINE BAND.

	COLSTERDALE.		COVERDALE.	UPPER NIDDERDALE.								
	Trial Holes near Gollingith Foot.	Spruce Gill.	West Scrafton Colliery,	Woo Gill.	Foggyshaw Lodge Coal Level.	Trope Scar.	Lul Beck.	West Gill, off Blagshaw Gill.	Backstone Gill, Meughe.	Stone Berk Head, Great Whernside.	Tops Gill, under Dead Man's Hill.	Stand Sike, under Dead Man's Hill.
PISCES.												
Acrolepis hopkinsi	×											
CEPHALOPODA												
Dimorphoceras gilbertsoni											?	
Glyphioceras diadema	?	×		?								×
,, *micronotum*	×											
,, *phillipsi*	×											
Orthoceras asiculare	×											
,, *koninckianum*	×											
Nomismoceras spirorbis											×	
LAMELLIBRANCHIATA.												
Allorisma sulcata				×								
Limatulina occidentalis				×								
Aviculopecten gentilis	×											
Pterinopecten papyraceus				?								
Ctenodonta lævirostris				×								
Edmondia sp.	×											
Leiopteria sp.				×								
Myalina peralata	×	×		?								
Nucula gibbosa	×											
,, *æqualis*				×								
,, *luciniformis*	×											
Nuculana attenuata	×			?								
,, *stilla*	×			×								
Posidoniella corrugata	×					×		×	×	×		
,, *kirkmani*								×				
,, *lævis*	×	×		×				×	×	×		
Posidonomya membranacea	×											
Prothyris elegans	×											
Schizodus antiquus				×								
BRACHIOPODA.												
Lingula mytiloides	×		×	×	×		×					
,, *squamosa*	×			×								
Orbiculoidea nitida	×											
Orthotetes	×											
Productus aculeatus	×											
Schizophoria resupinata	×										×	
Seminula ambigua	×											
GASTEROPODA.												
Bellerophon sp.	×											
Euphemus urei	×			?								
Macrocheilina brevispira	×											
Metoptoma sp.	×											
Ptychomphalus interstrialis ? ..	×											
Straparollus sp.	×											

TABLE III.

FAUNA OF THE CAYTON GILL BEDS.

	RIPON, PATELEY BRIDGE AND HARROGATE AREA.																MASHAM AREA.										
		Geological Survey.					Dr. W. Hind, *The Naturalist*, 1907.			Additional Records.							Lower Bands in series.								Upper Band.		
	Various localities, Tute.	Four Lane Ends, Harrogate.	Quarry behind Hampsthwaite Station.	Hampsthwaite Rly. Cutting.	Fountains.	Scargill Reservoir.	Clint Quarries.	Quarry near Pateley Bridge.	Hazel Hill, Sawley, near Ripon.	Hazel Hill (Trial Pit).	Fountains Quarry.	Roadmetal stated to be from Fountains Quarry.	Brimham Roadmetal Quarry.	Well sinking between Sawley and Oldfield.	Roundhill Reservoir.	Leighton Valve Shaft.	Near Fott Hall, Leighton (Daystones).	Near Linden Gill, Healey (Daystones).	High Ellington (well).	River Burn near Shaw's Pridge, Swinton.	Erratics, Leighton Reservoir ? off Towler Hill or Tranmire.	High Ash Head Moor.	High Ash Head Moor.	Arnagill Valley.	River Ure, North of Hackfall.
PISCES.																											
Acrolepis (scales)	×																										
Cladodus (teeth)	×																										
Pctalodus acuminatus							×																				
,, sp. (teeth)	×																										
Pleuroplax (tooth)															?												
Rhizodopsis sauroides							×																				
CEPHALOPODA.																											
Ephippioceras bilobatum									×																		
Glyphioceras sp.														×													
Nautilus	×																										
Orthoceras koninckianum														×													
,, *morrisianum*															×												
,, sp.	×						×		×																		
Pleuronautilus nodosocarinatus						×																					
Stroboceras bisulcatum															×												
,, *sulcatum*	×	×	×				×	×	×									×									
Temnocheilus tuberculatus			×																		×						
GASTEROPODA.																											
Bellerophon costatus	×																										
,, sp.															?		×										
Euomphalus sp.											×																
Euphemus sp.								×	×																		
Flemingia sp.																		×									
Loxonema rugifera								×																			
,, cf. *decoratus* (De Kon)									×																		
,, sp.																	×										
Macrocheilina ovalis																	×										
,, *gibsoni*									×																		
,, sp.																	×										
Naticopsis sp.									×																		
Raphistoma junior																			?								
Straparollus sp. (very small)															×												
LAMELLIBRANCHIATA.																											
Allorisma tumida																	×	×									
,, *sulcata*																				×							
Amusium concentricum								×																			
Aviculopecten clathratus												×						×		×		?					
,, *dissimilis*							×		×			×	×						×								?
Limatulina occidentalis																	×	×		×	×						
Aviculopecten (*murchisoni* group)													×							×							
,, *stellaris*									×																		
,, *semicostatus*									×																		
,, sp.	×							×									×										
Ctenodonta lævirostris															×												
Cypricardella parallela								×												×							
Edmondia m'coyi									×								×			×							
,, *senilis* (*rudis*)									×						×		×	×		×							
,, *sulcata*																	×					×					
Grammatodon cancellatus		?																									
,, *regularis*											×						×	×				×					
Leiopteria laminosa							×										×										
,, *squamosa*								×																			
,, *thompsoni*																		×									
,, sp.									×																		
Myalina peralata									×																		
,, *verneuilli*															×												
Mytilimorpha sp.									×																		
Nucula æqualis																				×		×					
,, *cadetonensis*															×												
Nuculana stilla																				×							
Palæolima striata									×																		
Pinna mutica																				×							
Posidoniella elongata																						×					
,, *lævis*														×								×					
Protoschizodus axiniformis															×		×										
,, *curtus*									×									×		×							
Posidonomya becheri	×																										
Pseudomusium fibrillosum														×													
Pterinopecten tesselatus															×												
,, *whitei*									×																		
Sanguinolites tricostatus																×				×							
Spathella lata																	×										
,, *modiolaris*							×		×	×								×									
Scaldia benedeniana																		×		×	×	×					
Schizodus antiquus																		×				×					
,, sp.																		×									
,, *wheeleri*																	×										
Sedgwickia transversa																	×										
Solenomya cylindrica																		×									
Tellinomorpha cuniformis									×																		
,, *transversa*																	×	×									
BRACHIOPODA.																											
Ambocœlia urei															×												
Chonetes hardrensis	×																										
,, *lagucssiana*							?		?						×				×				×				?
Derbya gigantea										×			×														
,, *hindi*	×			×			×	×	×						×		×					×		×	×		
Orbiculoidea nitida	×														?												
Lingula mytiloides															×	×											
Productus carbonarius															?		×										
,, *concinnus*																	×		×								
,, *cora*	×						×	×	×													×					
,, allied to *P. cora*																						×					
,, *longispinus*							×	×	×						?		×										
,, *punctatus*													×														
,, *aculeatus*	×																										
,, *scabriculus*							×															×					
,, *semireticulatus*	×																					×					
,, sp.				×	×																						
Pugnus pleurodon				×											?												
Riphidomella michelini	×							×							×												
Schizophoria resupinata	×	×			×		×	×	×	×	×	×			×		×										
Seminula ambigua							×	×							?							×					
Spirifer bisulcata		×	×																			×					
,, *lineata*	×																										
,, *striatus*	×	?																									
,, *trigonalis*	×																										
,, sp.													×														
Spiriferina cristata							×	×																			
,, sp.											×															×	
POLYZOA.																											
Fenestella sp.								×															×				

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